Hydrothermal Processing of Lignin for Bio-Crude Production

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Hydrothermal Processing of Lignin for Bio-crude Production

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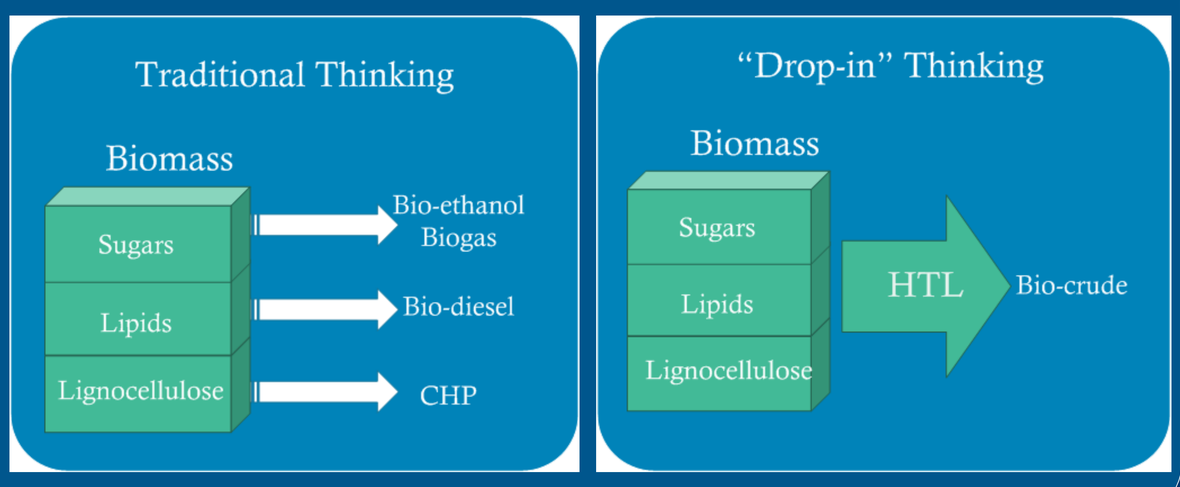
Hydrothermal liquefaction (HTL) uses high pressure (10 – 35 MPa) and intermediate temperature (280˚C – 400˚C) to convert wet biomass into bio-oil and residual streams of solids, water soluble substances and gas.
There are a wide range of biomass feedstocks on the globe that can be converted through a variety of technologies to provide heat, electricity and transport fuels. Low value wastes can become a sustainable source for bio-crude production. They are residuals resulting from different processes which can become feedstocks for other processes, as well as for HTL. 10 billion metric tons of agricultural residues are being produced every year worldwide and 1.3 billion tons of solid waste is generated by the world cities [1,2]. These low value wastes are expected to increase in time with the degree of urbanization, economic development and resource-intensive lifestyle [2].
But in a world where the fuel consumption is about 90 million barrels oil equivalent (Mboe) per day, and with an oil production capacity questioned constantly, together with the increasing CO2 emissions, a new way of providing energy has to be developed. The most efficient way forward is to work with so-called drop-in fuels, which meet the quality specifications of crude-oil, diesel, gasoline or jet fuel.

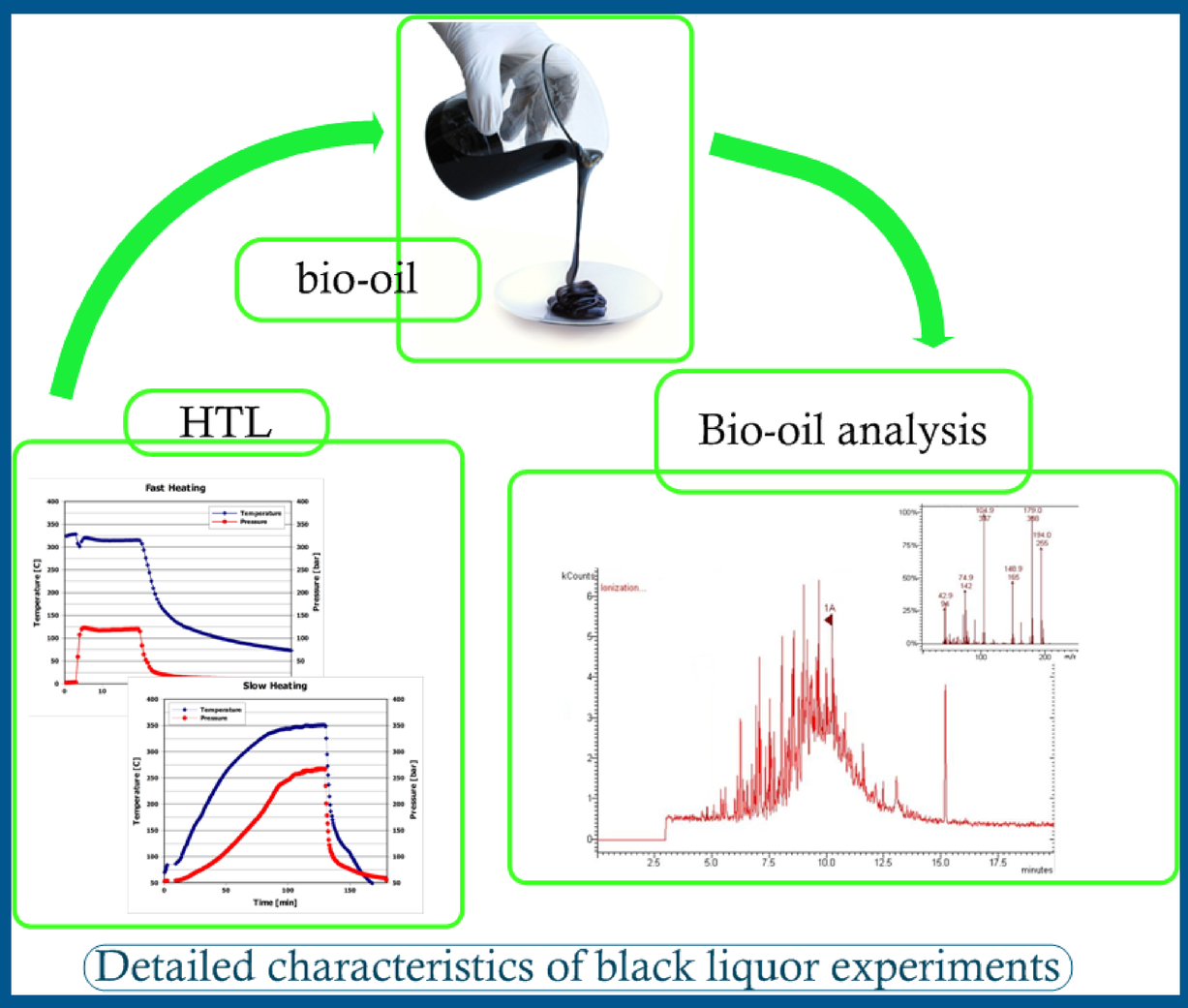
From Biomass to Biofuel



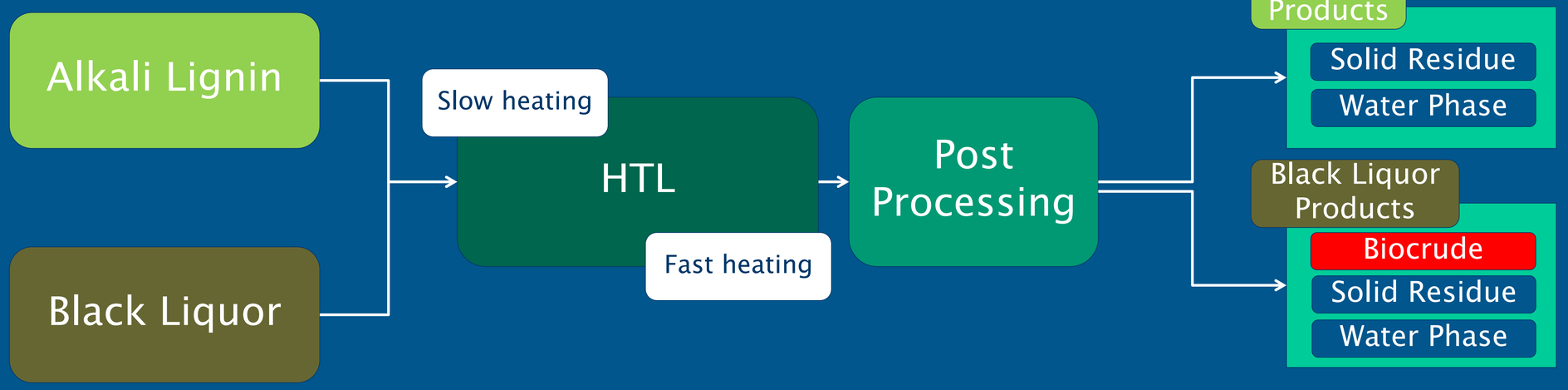
Types of Experiments

Two types of experiments were carried out with Alkali Lignin and black liquor: the slow heating and fast heating. "Slow heating" of Alkali Lignin and black liquor means that the feedstock was loaded in the reactor and heated to the reaction conditions, while the "fast heating" type implied the injection of the biomass feedstock when the reactor was at the desired conditions.
HTL conversion of Alkali lignin produced 3 different streams: a water stream, solids and gases. In the case of black liquor experiments, the HTL conversion also resulted in a product stream (bio-crude),The oil phase was analysed by gas chromatography – mass spectrometry (GC/MS), CHNS, while the solid residues were analysed by Fourier Transform Infrared (FTIR) and CHNS. All yields were calculated based on a total dry matter.

Black Liquor to Bio-crude: Experiments

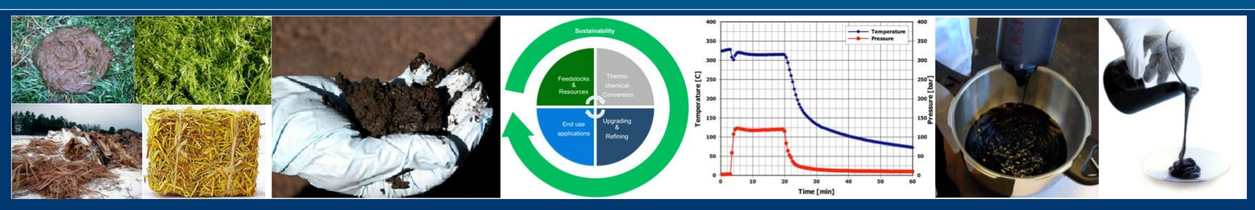


HTL Process Diagram



Results

- No oil phase was obtained from the Alkali lignin HTL at the respective conditions. However, the study showed that lignin mixed with hemicellulose (mixture known as black liquor) can lead to bio-crude.
- Around 80-90 % of the organic part of the feedstock is converted;
- The optimal conditions for black liquor liquefaction are 300°C if an injection system is used and 350°C if black liquor is "slowly heated";
- Around 90 % of the input black liquor energy is recovered into oil phase;
- The target conversion ratio of one third of the dry matter into oil was achieved in the experiments;
- The highest oil yield obtained for black liquor HTL conversion was of 36 % at 350°C when black liquor was slowly heated;
- The highest HHV of bio-oil obtained from black liquor conversion was of 34.7 MJ/kg at 360°C;
- GC/MS results showed that the following compounds are found in the bio-crude coming from black liquor hydrothermal liquefaction: hexadecanoic acid, dehydro-abietic acid, 1,2-benzenediol, acetophenone, 1-methyl-3,5-benzenediol, 2-hydroxyphenyl-ethanol;
- CHNS results revealed that the oxygen content in bio-crude from hydrothermal liquefaction is much lower than the bio-crude from pyrolysis. The oxygen content varied in the range 15-35 % compared to pyrolysis, which oxygen content is in the range 35 -45% [4].
- About 40 Mboe/day of bio-crude can be obtained from the liquefaction of 10 billion tons of agricultural residues, if a dry matter of 80 % and an oil yield of 30% is assumed, which means that almost half of today's global consumption can be covered through efficient, sustainable production of bio-crude.



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